Singapore: Moving Ahead With the Second Industrial Revolution

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An Intelligence Assessment

EA 82-10055
May 1982

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Directorate of
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Information available as of 5 May 1982
has been used in the preparation of this report.

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The author of this paper is [redacted] of the Office of East Asian Analysis. Comments and queries are welcome and may be directed to the Chief, Southeast Asia Division, OEA, [redacted]

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This paper has been coordinated with the National Intelligence Council. [redacted]

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Singapore's International Economic Importance

In the World Economy

- *The world's second-busiest port.*
- *The second-largest builder of offshore drilling rigs.*
- *The third-largest oil refining center.*
- *The commercial, financial, and communications hub of Southeast Asia.*

To the United States

- *Over 650 American firms have investments in Singapore with fixed assets totaling nearly $3 billion.*
- *In 1981, the United States was Singapore's largest market, importing an estimated $2.7 billion.*
- *In 1981, the United States was Singapore's third-largest supplier after Japan and Saudi Arabia, exporting goods valued at $3.5 billion.*

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Singapore: Moving Ahead With the Second Industrial Revolution

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Key Judgments

Prime Minister Lee Kuan Yew is pressing ahead with Singapore's "Second Industrial Revolution" to move the city-state into the knowledge-intensive and high-technology manufacturing industries that are emerging in the 1980s. Singapore is:

- Developing capabilities in computer software, engineering design, and financial and professional services.
- Encouraging the establishment of research and development and high-technology manufacturing facilities in fields such as industrial electronics, avionics, optics, and specialized oilfield equipment.
- Upgrading university education in advanced software and expanding technological training for skilled workers, tapping West European, Japanese, and US expertise.

Singapore is in the forefront of the newly industrializing countries in offering incentives to multinational firms to move into the knowledge-intensive industries, and Lee is determined to maintain this lead. The government uses a mix of tax incentives to attract multinational firms and to encourage the transfer of advanced technology. With its small internal market and lack of natural resources, Singapore will remain dependent on advances in innovation and gains in productivity to continue its real economic growth rate of more than 9 percent annually since the 1970s.

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Singapore: Moving Ahead With the Second Industrial Revolution

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The First Industrial Revolution [1]

Singapore faced an uncertain future with no significant natural resources when it separated from the Malaysian Federation in 1965. Its major assets were an excellent, strategically situated harbor, a disciplined labor force; and, most importantly, an effective government headed by Prime Minister Lee Kuan Yew, a leader who saw economic success as the key to the survival of the city-state.

Over the next decade and a half, Singapore transformed its economy from an entrepot for neighboring Malaysia and Indonesia into a regional financial, commercial, and service center, with a diversified manufacturing base that put it in the ranks of the middle technology industrializing countries along with South Korea, Taiwan, and Hong Kong. The share of manufacturing (including oil refining) in GDP grew steadily from less than 15 percent in 1965 to 28 percent by 1980 as Singapore developed oil refining and electronics industries from scratch and took advantage of the start of offshore oil exploration in Southeast Asia to become the central supply base for the industry throughout the region. Initially emphasizing its low labor costs as an inducement to foreign investors, the government shifted in 1973 to seeking more capital- and technology-intensive investment to reduce Singapore's vulnerability to competition from poorer countries in traditional export lines such as textiles, footwear, and furniture.

The Ingredients of Success

An Activist Government

The government has pursued an interventionist role primarily directing private investment by means of tax incentives. It has succeeded in keeping gross domestic capital formation above 35 percent of GDP each year for more than a decade—a rate of investment roughly comparable with Japan's.[2] Singapore has established a number of public entities to assist private investment. The Economic Development Board, the government's key institution for directing private investment, has targeted tax incentives to encourage investment in high-technology industries such as electronics, avionics and aircraft components, advanced medical equipment, precision engineering and optical equipment, and process engineering equipment. Firms investing in these industries are eligible for:

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- Accelerated depreciation on fixed investment.
- Tax holidays for five to 10 years.
- Tax exemptions on export profits.

The Economic Development Board also has established a solid track record in upgrading the skills of workers either in conjunction with private firms or in government-operated institutions. Since 1972, four industrial training centers have been established with assistance from foreign firms and governments to provide two-year courses in such fields as precision machining, tool and die making, optics, and instrumentation. In addition, the government has spurred technical training for secondary school graduates by establishing the Vocational Institute Training Board, which operates 17 institutes covering the entire spectrum of technical skills.

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In fields where private investors have been unable or unwilling to invest or in which the government feels an overriding public interest, Singapore has established state-owned firms or formed joint ventures with private partners. Prominent examples are Singapore Airlines, the Singapore Refining Company, and, most recently, the Singapore National Oil Company, which according to Singapore officials was formed to assure sufficient oil stocks in the event of any disruption in supplies.

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[2] This consistently high rate of investment, involving spending on construction and productive assets such as machinery and equipment, has helped assure Singapore's high economic growth rate even when external demand for exports has weakened.

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Singapore:
Oil Refining and Related Activities

Refinery	Opening Date	Atmospheric Crude Distillation Capacity (Barrels Per Day)	
		Original	1981
Shell	1961	30,000	460,000
British Petroleum	1962	20,000	27,000
Mobil	1965	25,000	195,000
Exxon	1970	80,000	192,000
Singapore Refining	1973	65,000	170,000

Offshore Oil Rig Construction
Five shipyards have made the island republic the world's second-largest builder of offshore oil rigs, trailing only the United States.

Support Activities for Offshore Oil Exploration
- *Geophysical services.*
- *Diving, underwater construction, and pipeline laying.*
- *Construction, repair, and maintenance of offshore rigs, marine service vessels, barges, and tugs.*
- *Equipment storage facilities.*
- *Fabrication of pressure vessels, boilers, heat exchangers, and prefabricated modular structures for offshore rigs.*
- *Supply of corrosion-resistant coatings, valves, and measuring equipment.*

Petrochemical Complex
A Japanese consortium led by Sumitomo Chemical is constructing a $1 billion complex to produce feedstocks for Asian plastics and fiber industries. A $500 million naphtha/gas oil cracker will produce 300,000 tons of ethylene and 160,000 tons of propylene annually as feedstocks for six downstream plants producing glycol/ethylene oxide, high-density polyethylene, low-density polyethylene, and polypropylene.

International Petroleum Center
The Governmnent of Singapore, with financial support from Kuwait, plans to create an International Petroleum Center to provide the entire range of technical support needed by the petroleum industry in Southeast Asia.

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The Role of the Multinationals
Throughout the 1970s, foreign investors accounted for over 70 percent of the total commitments in manufacturing and now dominate key industries. According to the US Embassy, multinationals find Singapore a desirable place in which to invest because of its open economy, stable political climate, tax incentives, productive and docile labor force, and the availability of first-rate transportation, banking, and communications facilities. Some, particularly the American and West European electronics firms, first established operations there because of the presence of a trainable labor force. Others, like the Japanese, have used Singapore as a means of gaining entry to third-country markets.

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Singapore: Major Foreign Investment in the Electronics Industry

US firms	Products
Coors	Ceramic substrates
CTS	Potentiometers
Digital Equipment Corporation	Computer equipment and parts
DuPont	Connectors
Fairchild	Semiconductors, semiconductor test equipment technical support center
Foxboro	Process control systems
General Electric	Consumer electronics products and electronics components
General Motors	Automotive electronics
Hewlett-Packard	Oscilloscopes, electronic calculators, data cartridges, analogue meters, and computer subassemblies
Honeywell-Synertek	Semiconductors
Litton Industries	Solder products
Molex	Connectors
National Semiconductor	Semiconductors
Printed Circuits International	Printed circuit boards, liquid crystal displays, and programmable thermostats
Texas Instruments	Semiconductors
Union Carbide	Dry cell batteries
Veeco	Power supplies
West European firms	
Crompton Parkinson	Electrical measuring instruments
Data Recording Heads	Magnetic heads for disk drives
Demetron	Printed circuit boards
Elektrisk Bureau	Communication equipment
Luxor	Color TV sets
Olivetti	Printing calculators
Philips	PABX systems and consumer electronics products
Preh-Werke	Potentiometers and switches
SGS-Ates	Semiconductors
Siemens	Lasers, liquid crystal displays, flash tubes, capacitors, and semiconductors
Thomson Brandt	Consumer electronics products, TV tuners, relays, and thermostats
Thomson CSF	Semiconductor testing
Varta	Nickel cadmium and silver oxide batteries
Woelke	Magnetic heads for disk drives, dictaphones, and film projectors
Japanese firms	
Aiwa	Consumer electronics products
Foster	Speakers and hi-fi amplifiers
Hitachi	Color TV picture tubes, consumer electronics products, and printed circuit boards
Hokushin	Process control equipment
JVC	Consumer electronics products
Matsushita	Consumer electronics products, electronic components, and precision micromotors
Meidensha	Quartz crystals
Mitsubishi	Consumer electronics products and monochrome TV picture tubes
Murata	Ceramic multilayer capacitors, resistors, and filters
Nippon Electric Corporation	Fluorescent displays and semiconductors
Nippon Miniature Bearing	Consumer electronics products and components, stepper motors, and printing calculators
Sankyo Seiki	Level meters and magnetic tape heads
Sanyo	Consumer electronics products and microwave ovens
Toshiba	Consumer electronics products
Trio-Kenwood	Hi-fi equipment
Yokogawa Electric	Measuring and indicating instruments and electronic thermometers.

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Semiconductor Manufacturing and Technology

The small size and low power requirements of the semiconductor since it was invented in the United States less than four decades ago have given rise to a giant global industry. The development of the integrated circuit (IC), an array of components such as diodes and transistors interconnected on a single silicon chip to form complex integrated circuits, spurred two major trends—the vertical integration of the industry and the spread of labor-intensive operations overseas. Because ICs constitute such a large share of the value of some products, many semiconductor manufacturers found it technologically and economically feasible to produce finished products such as calculators and watches. Conversely, some makers of computers, telecommunications gear, audio and video equipment, and other electronics products found it advantageous to develop their own IC manufacturing capability.

Manufacture of semiconductor chips requires high-purity materials, solid-state technology and processing equipment, and specialized skills in physics, electrical engineering, chemistry, and metallurgy.

From the chemical processes used to make semiconductor-grade silicon ingots to slicing the brittle wafers—typically 4 inches in diameter—from the ingots, and the sequence of steps required to create integrated circuits on the wafers, the processes require a carefully controlled environment in highly sophisticated plants. The next stage—dicing the wafers into fingernail-size chips—involves either scribing the wafer with a diamond cutting tool or, in more modern plants, engraving the wafer with a high-power laser beam and cracking the wafer along the pattern marks. Up to this point, most processing typically is performed within a single plant. The next stage, increasingly automated, involves the assembly of chips into usable components and often takes place in plants halfway around the world from the original processing plant. At this stage, the chips are mounted into packages, usually metallurgically bonded, attached to external electrical connections, and enclosed within metal and ceramic or molded plastic protective packages. Final testing is invariably computer controlled because of the complexity, precision, and number of tests required before assembling the devices into finished products.

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Moving Up the Technology Curve

The multinationals have been in the forefront of Singapore's technological advance, with the electronics industry the most striking example of introducing advanced technology. Beginning with one black-and-white television assembly plant in 1965, electronics firms have steadily upgraded their technological capabilities by shifting from simple labor-intensive assembly operations to production of complete electronics products and to more skill intensive and automated assembly operations. Although it is still highly labor intensive, Singapore's industry made a quantum jump in 1981 when two firms made investment commitments for plants to fabricate semiconductor wafers. After the plants begin operating in the next few years, Singapore will move beyond the initial stage of producing simple integrated circuits to more complex ones.

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Even in oil refining, Singapore has steadily upgraded its technology base. Rather than simply expanding crude distillation capacity, refiners have concentrated on adding secondary processing facilities in recent years to upgrade the product mix and handle a wider variety of crudes. At present, Shell is constructing a 22,000 b/d hydrocracker in Singapore—only the second such Shell unit outside North America—which

will allow it to produce a higher proportion of light products (such as gasoline) per barrel of crude. Other refineries have added similar facilities and are pushing ahead with such projects as catalytic crackers and reformers, visbreakers, desulfurizers, and other equipment that will keep Singapore's refineries technologically modern.

The Second Industrial Revolution

In 1979, Lee began a major gamble on another transformation of Singapore's economy for the 1980s. In what has been billed as Singapore's "Second Industrial Revolution," the government has set out to make Singapore a high-technology manufacturing center and a regional center of the knowledge industries that provide consulting services in the fields of computer software, engineering, architecture, and design, as well as the entire range of medical and other professional services. Lee's goal is to create a highly educated corps of specialists that will both enhance Singapore's existing economic base and enable it to take advantage of whatever new opportunities arise in the 1980s.

The most widely felt effect so far has been a government-mandated increase in wages designed to discourage low-skilled operations from locating in Singapore and to encourage existing low-wage manufacturers to upgrade their operations. The wage increases averaged over 20 percent annually in 1979 and 1980 and about 16 percent in 1981.[3] The Economic Development Board has taken steps to spur capital- and technology-intensive investments, including:

- Establishing a Skills Development Fund financed by a payroll tax to provide assistance to firms seeking to upgrade employees' skills.
- Establishing several government bodies to oversee various phases of technological advance, including the Committee on National Computerization and the National Computer Board.
- Introducing generous new financial incentives for investments in research and development.

[3] Despite the rapid gains, wage increases in Singapore remained in line with other Asian newly industrializing countries. Wage rates in Taiwan, for example, rose an average of nearly 18 percent annually from 1978 to 1981.

The Technology Training Institutes

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The institutes established by the West German and French Governments aim at a broad range of advanced technological skills. The German-Singapore Institute, which is to begin operations in 1982 with a planned initial enrollment of 400, will train production engineering technicians in machinery processes, tool and die making and design, and other processes. About one-half the cost of the $18 million installation will cover machinery and training equipment from West Germany. Half will pay German instructors and provide scholarships for trainees to be sent to West Germany.

The $10 million French-Singapore Institute is scheduled to open in April 1983 also with a planned initial enrollment of 400. It will train technicians in electrotechnology with a strong emphasis on control engineering instrumentation, microprocessor and computer applications, and robotics.

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The Japan-Singapore Institute of Software Technology will focus more directly on computer applications. It has begun selecting applicants for its first class in 1982. Financed by the Japanese Government and operated by a consortium of Japanese firms led by Nippon Electric Corporation, one of Japan's leading electronics manufacturers, the institute will offer professional training in software technology.

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- Establishing a Science and Technology Park adjacent to the National University of Singapore to encourage investors to establish R&D facilities in Singapore.

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The Economic Development Board also sought assistance from foreign governments and firms to establish new training institutes in advanced technology. The obvious mutual benefits quickly won approval from

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Bonn, Paris, and Tokyo. IBM also agreed to set up an Institute of Systems Science to teach postgraduate courses in programing and systems analysis in partnership with the National University of Singapore.

Thus far, Singapore's strategy seems to be paying off. National Semiconductor, for example, increased capital investment from $575 per employee in 1977 to $5,750 in 1980. Singapore has also been successful in attracting the types of investment Lee wants. In 1981 alone, foreign firms either expanded existing operations or opened new plants to produce:

- Mainframe, minicomputer, and microcomputer systems and peripheral equipment.
- Electronic office equipment.
- Semiconductor wafers, printed circuit boards, and laminates.
- Programmable thermostats and automotive electronic displays.
- Directional oil drilling equipment.
- Intermediate chemicals for antibiotics.

Despite the world slowdown in the electronics industry, increasing capital- and technology-intensive investment has made Singapore less vulnerable to swings in export demand for semiconductors. In a recent press report on the current global downturn in the industry, National Semiconductor, which has been shortening workweeks and laying off some of the 20,000 workers in its eight Asian plants, reported that its "Singapore and Hong Kong plants have been the least affected because they make hybrid and microcomputer products."

Shaping the Revolution

Lee and First Deputy Prime Minister Goh Keng Swee, who were the architects of the "First Industrial Revolution," are in overall command of the current development program. Implementation of the effort, however, is in the hands of the "Gang of Seven," a group of younger technocrats who have been appointed to leading positions, including five ministries, in the past few years. With his concern over Singapore's economic future matched by his desire to assure political leadership in the 1980s and beyond, Lee has actively recruited talented candidates to government service and thrust them into positions of responsibility to test their capacity for growth. The seven have strong technical credentials from varied educational and professional backgrounds, with solid records of achievement both in the private sector and in government assignments. Several have done graduate study in the United States and other countries and subsequently served in the Ministries of Finance, Trade and Industry, the Economic Development Board, and the Development Bank of Singapore. All are fully attuned to Lee's economic development goals. 25X1

Lee's authoritarian approach to government will ease the task of the technocrats in restructuring Singapore's economy. The government frowns on strikes and other labor disruptions because of the potential damage to export competitiveness and to attracting foreign investors. Through a combination of wage increases and threats against any labor union action that could be construed as a challenge to the government, Lee has achieved a remarkable degree of labor peace over the years. Indeed, the last recorded work stoppage occurred in 1977. 25X1

The government influences wage policy through the National Wages Council, a tripartite organization representing labor, management, and the government. The Council's recommendations, which have closely adhered to Lee's wishes over the years, carry the weight of government decisions. Despite occasional grumbling, both labor and management invariably accept the wage recommendations. 25X1

The government also assures itself a strong direct voice in labor affairs. One of the "Gang of Seven," Lim Chee Onn, has served as secretary general of the National Trades Union Congress, Singapore's blanket labor organization, since 1979. In this position, he acts not only as labor's spokesman to the public but also represents the People's Action Party, Lee's ruling party, in labor council deliberations. 25X1

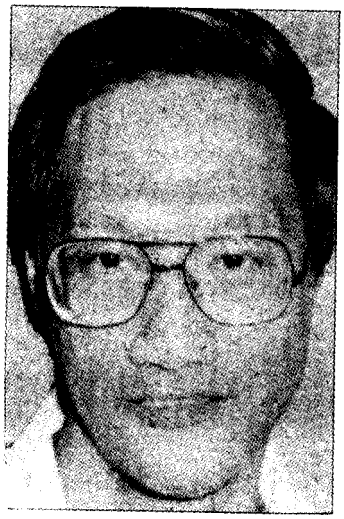
Lee is free of political constraints in implementing any economic program. The government has all but eliminated the political opposition by denying it a platform in the government-controlled media, and Lee's party controls all but one seat in the 75-member parliament. Singaporeans are generally content with

Leading Technocrats

Goh Chok Tong
Age 40

Straits Times ©

Minister of Health and Second Minister of Defense since June 1981; first of the "Gang of Seven" to achieve ministerial rank; educated in Singapore and the United States (economics).



Lim Chee Onn
Age 37

Straits Times ©

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Minister Without Portfolio since September 1980; Secretary General of the National Trades Union Congress; educated in the United Kingdom (naval architecture) and the United States (public administration).

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Tony Tan Keng Yam
Age 41

Straits Times ©

Minister of Trade and Industry since June 1981; educated in Singapore (physics), the United States (operations research), and Australia (Ph. D. in mathematics).

Suppiah Dhanabalan
Age 44

Straits Times ©

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Minister of Foreign Affairs since June 1980; served in Ministry of Finance, EDB, and helped establish the Development Bank of Singapore; educated in Singapore (economics).

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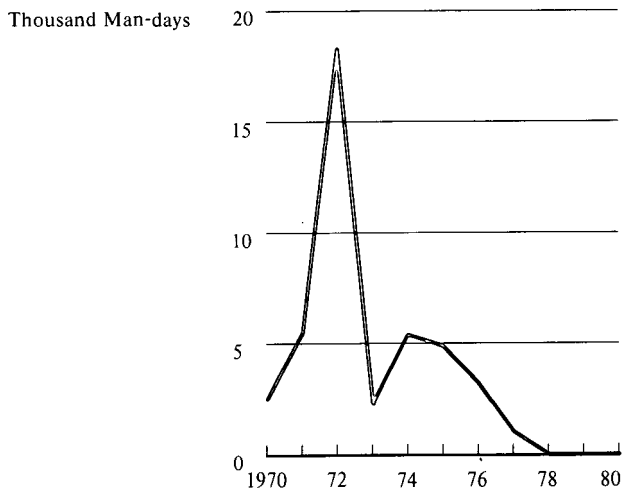
Singapore: Days Lost in Work Stoppages



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Lee's autocratic, but competent, leadership and attribute their high standard of living to his policies. Any overt dissatisfaction would be checked by unspecified, but clearly understood, government limits to open discussion of political issues.

Competitiveness in the 1980s . . .

Singapore's demonstrated flexibility and energetic preparations for the 1980s suggest that it will successfully maintain its competitive edge in world markets. Among the newly industrializing countries in Asia, Singapore is in the forefront in providing incentives for a move into knowledge-intensive and high-technology industries. Although the other countries will emulate some of these policies, Singapore has a lead in attracting multinational firms that will, in turn, aid efforts to advance the technical capabilities of the labor force.

Lee hopes his decision to make English the language of instruction in the school system and the language of government and business will enhance Singapore's effort to attract investment in advanced services and software industries. Analysts frequently cite language difficulties as a major drawback in the development of these industries in other Asian countries. The language barrier in Japan, for example, has hindered that country's efforts to develop advanced software capabilities to match its advances in developing computer hardware. 25X1

Manufacturing will remain a key element in Singapore's economy throughout the 1980s, and it will be increasingly diversified to serve regional and global markets and to complement Singapore's drive to develop high-value service capabilities in software and the knowledge industries. Singapore's efforts to combine manufacturing and services are coming to fruition in the planned International Petroleum Center. The Center will contain hardware and software capabilities to support the entire range of petroleum operations—from analyzing seismic data on potential crude oil reservoirs to transportation and marketing of refined products. Singapore plans to develop similar capabilities in other fields, such as mining, and thus make itself a headquarters base for resource-based industries and firms operating throughout Southeast Asia. 25X1 25X1

The major stumblingblock to achievement of Lee's goals will remain the extremely tight labor market that has characterized Singapore's economy for nearly a decade. Singapore shows every sign of successfully overcoming this obstacle, however. Spurred by the tight labor market and tax incentives, firms are rapidly automating their production lines to improve productivity and quality control. Manufacturers have introduced computer numerically controlled tools into operations as diverse as making molds for ophthalmic lenses and producing precision machine tools. Robots are being introduced in certain of Singapore's manufacturing operations such as spray painting and automatic injection molding. 25X1 25X1 25X1

Although Singapore is still far from being able to compete with the world leaders in high-technology manufacturing, the drive for more and advanced automation has yielded impressive results in the past two years. Despite the global economic slump, Singapore achieved real economic growth of nearly 10 percent in 1981 aided by a labor productivity gain of 5.4 percent, more than double the previous year's performance. Manufacturing showed a 9.6-percent gain in productivity and should continue above average in the next few years. To date, Singapore's success in boosting productivity has kept labor costs competitive with Taiwan and Hong Kong despite the large wage gains granted since 1978.

Achievement of educational goals will be the key to Singapore's future success. By 1985, Singapore plans to graduate 1,200 engineers annually, compared to 300 now. Plans also call for 5,000 technicians and 10,000 skilled craftsmen (precision machinists, tool and die makers, and mold makers), compared to current annual rates of 1,200 and 3,000, respectively. More importantly, doubling university enrollment and expanding advanced computer software capabilities will determine whether Singapore can successfully take advantage of the regional and global economic opportunities arising in the 1980s. What is certain is that the preparations currently under way will improve Singapore's ability to grasp new opportunities.

. . . Vis-a-Vis the United States

Singapore's efforts to upgrade technology and maintain competitiveness will enhance its attractiveness to US firms and continue to provide profitable investment and export opportunities for them. At the same time, Singapore is likely to capture a larger share of service markets that are now dominated by US and other foreign firms. In oil-related activities, for example, Singapore will expand its role as a testing and analysis center, performing laboratory functions that have traditionally been concentrated in other major petroleum centers such as Houston. 25X1

In export markets, Singapore almost certainly will not compete in the broad range of electronics product exports to the United States that Japan has so successfully developed. More than likely, Singapore will find market niches similar to those exploited by smaller firms in the American electronics industry. Indeed, a number of small firms have already been established in Singapore by former employees of some of the major multinationals to provide specialized services or parts to larger plants. 25X1

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